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Recent work by the CUNY group under the direction of Professor Louis Auslander has continued to study application of the Weil transform to radar signal processing and, in a parallel effort , to multi-access spread spectrum communications. The main thrust of the work is the relationship between the Weil transform of a waveform and the ambiguity surface of the wave-form. The study of this relationship has led to a fundamental observation: the cancellation properties of a waveform necessary for the creation of a thumbtack-like ambiguity surface may be viewed as arising from the pattern of zeros and the non-trivial winding numbers of the Weil transform of the waveform. This point of view is exposited and used to reinterpret classical radar waveform design techniques, while also providing a new method for radar waveform design. Additionally, a new technique for modifying or "shaping" waveforms has been developed. This consists of changing a waveforms has been developed. This consists of changing a waveform by multiplying its Weil transform by doubly-periodic functions and taking the inverse Weil transform to produce a new signal.

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Professor Louis Auslander, Principal Investigator

Recent work by the CUNY group under the direction of Professor Louis Auslander has continued to study applications of the Weil transform to radar signal processing and, in a parallel effort, to multi-access spread spectrum communications. The main thrust of the work is the relationship between the Weil transform of a waveform and the ambiguity surface of the waveform. The study of this relationship has led to a fundamental observation: the cancellation properties of a waveform necessary for the creation of a thumbtack-like ambiguity surface may be viewed as arising from the pattern of zeros and non-trivial winding numbers of the Weil transform of the waveform. This point of view is exposited and used to reinterpret classical radar waveform design techniques in [10], while also providing a new method for radar waveform design. Additionally, a new technique for modifying or "shaping" waveforms has been developed. This consists of changing a waveform by multiplying its Weil transform by doubly-periodic functions and taking the inverse Weil transform to produce a new signal.

Recently, an effort has begun to extend the range of application of the circle of ideas involving the Weil transform to problems in spread spectrum communications. The connections between radar ambiguity problems and communication theory are classical: two waveforms both having thumbtack-like ambiguity surfaces and having a nearly flat cross-ambiguity surface may be useful as communication "symbols" in the transmission of information. Progress has been made in the use of the Weil transform to design such communication waveforms. The results of this investigation and its relationship to some recent engineering literature will be presented in [8].

These studies of the Weil transform have resulted in a series of papers both theoretical and experimental. The papers [6] and [7] present connections with the multiplier theory of classical harmonic analysis and with the bandwidth analysis of functions found in the classical papers of Slepian,

Landau, and Pollack. In [5] we have presented a series of numerical studies, viewed as either experiments with or applications of the theory in [6] and [7]. Included in this are waveforms having the property that the radar returns from such a waveform may be decomposed into components living on different scales. An example of such a waveform is presented together with numerics clearly indicating its success in providing a multiresolution analysis of radar returns. Another construction produces waveforms having ambiguity properties similar to given waveforms while having significantly better bandwidth properties.

Currently we are continuing our theoretical work on the use of the Weil transform in constructing communications signals, while also furthering our work on the multiresolution application mentioned above. We hope in the future to extend the range of application of these ideas to general feature extraction, with the problem of automatic speech recognition as the motivating example.

References

[1] L. Auslander, "Sliding windowed Fourier transforms and the Heisenberg group," *Acoustic Signal Processing for Ocean Exploration*, J. M. F. Moura and I. M. G. Lourtie (eds.), 1993.

[2] L. Auslander and F. Geshwind, "Multi-target ambiguity functions," *Acoustic Signal Processing for Ocean Exploration*, J. M. F. Moura and I. M. G. Lourtie (eds.), 1993.

[3] L. Auslander and F. Geshwind, "Approximate Frames and the Multi-Target Radar Problem," to appear in *Proceedings of the 1992 NATO ASI on Wavelets and Their Applications*.

[4] L. Auslander, F. Geshwind, and F. Warner, "A New Approach to Radar Waveform Design," research proposal submitted to ARPA, 1993.

[5] L. Auslander, F. Geshwind, and F. Warner, "Radar waveform design and the Heisenberg group," submitted for publication.

[6] L. Auslander, F. Geshwind, and F. Warner, "Weil multipliers," submitted for publication.

[7] L. Auslander, F. Geshwind, M. Saadia-Otero, and F. Warner, "The Weil transform and bandwidth," submitted for publication.

[8] L. Auslander and F. Warner, "Channel coding and the radar ambiguity function," in preparation.

[9] R.E. Blahut, "Theory of Remote Surveillance Algorithms," *Radar and Sonar, Part I*, R.E. Blahut et. al. (eds.), Springer-Verlag (1991).

[10] F. Geshwind, "The Weil Transform and Ambiguity Functions," Thesis, CUNY, 1993.